MATERIALS BUREAU

TECHNICAL REPORT 94-4

WEARING SURFACES FOR STEEL ORTHOTROPIC BRIDGE DECKS

APRIL 1994

M.A.P. CODE 7.42-6-94-4

NEW YORK STATE DEPARTMENT OF TRANSPORTATION
MARIO M. CUOMO, Governor
JOHN C. EGAN, Commissioner

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WEARING SURFACES FOR STEEL ORTHOTROPIC BRIDGE DECKS

FINAL REPORT

Conducted in conjunction with the
U.S. Department of Transportation
Federal Highway Administration
Experimental Feature Project Number 80-09 A-B

Prepared by

Harold P. Sloan
Civil Engineer I

April 1994

MATERIALS BUREAU
WAYNE J. BRULE, DIRECTOR

NEW YORK STATE DEPARTMENT OF TRANSPORTATION
1220 WASHINGTON AVENUE, ALBANY, NY 12232

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I. INTRODUCTION

A. Background

The New York State Department of Transportation owns and maintains two orthotropic steel plate deck bridges. On each of these structures, the deck wearing surface has shown signs of distress shortly after initial installation was complete. Disbondment and sliding of the wearing surface over the steel deck plates has been common. To correct this problem, each bridge was reconstructed in 1981 using an experimental wearing surface system.

B. Purpose

This study is being conducted in conjunction with Experimental Feature Project NY 80-09 A-B "Wearing Surfaces for Steel Orthotropic Bridge Decks." The purpose of this study is to evaluate the protective, bonding, and durability characteristics of wearing surfaces on steel plate bridge decks.

This report describes the performance of two experimental wearing surface systems on orthotropic bridge decks. Additional details on the design and reconstruction of these orthotropic decks are reported in Technical Report 84-4, Wearing Surfaces for Steel Orthotropic Bridge Decks, dated June, 1984.

II. TEST SITES AND WEARING SURFACES

A. Webster Street Test Site - Cities of Tonawanda and North Tonawanda

This structure consists of two lanes and carries Webster Street over the Barge Canal between Erie and Niagara Counties. The steel orthotropic deck was originally constructed in 1978. The bridge is 214½ feet long by 50 feet wide and consists of two, 107 foot simple spans, built on a crest vertical curve connecting 3.3% and 3.8% grades. Traffic lights which account for stop and go movements are located at each end of the structure.

The bridge was rehabilitated in 1981 under Contract No. D96775, P.I.N. 5940.03.303. Work consisted of removing the existing wearing surface and replacing it with an experimental wearing course system. This new system consisted of applying a preformed sheet waterproofing membrane and paving a 2 inch thick asphalt wearing surface. The preformed membrane in this system was "Bituthene 5000" as manufactured by W.R. Grace and Co., Cambridge, MA.

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B. Whitehall Test Site (South Bay Bridge)

This structure consists of two lanes and is located on NY Route 22, north of Whitehall, over the South Bay of Lake Champlain. The original bridge was built in 1973 on a crest vertical curve, connected by 2% grades. The structure is 530 feet long by 42 feet wide and consists of six - 88 foot long simple spans.

In 1981, the South Bay Bridge was reconstructed under Contract No. D96636, P.I.N. 1130.27.321, F.A. Project No. FR-73 (102). The work consisted of removing the existing wearing surface, stiffening the steel deck plates to reduce flexibility, and placing an experimental wearing surface system. The new wearing system consisted of painting the steel deck with an inorganic zinc-rich paint for corrosion protection; the application of an asphalt emulsion tack coat to enhance bonding; a first course paving of asphalt concrete (1-1½ inch thick); the application of a fabric membrane for waterproofing; and, a second course paving for a wearing surface of asphalt concrete (1-1½ inch thick). The fabric membrane in this system was "Petromat Fabric" (5 oz/s.y.), Bridge Deck Membrane Grade, as manufactured by Phillips Fibers Corporation, Greenville, South Carolina.

III. PERFORMANCE EVALUATIONS

Distress surveys were conducted at both locations to evaluate each wearing course system's performance. A summary of the findings is discussed below.

A. Webster Street Bridge

This wearing course system showed no evidence of deterioration thru its first two years of service.

A survey in the fall, 1984 (3 years old), revealed a slight displacement, or shoving, of the asphalt deck in the location of the traffic lights, at the most northern and southern expansion joints. In addition, a 1-inch rut was observed in the outer wheelpath of the northbound lane in the area of the 3.8% grade where motorists start and stop for the traffic light.

A final survey was conducted in 1989 after 8 years of service. The shoving condition had progressed. In the northbound lane both wheelpaths showed some rutting for the entire bridge length, and at the northern expansion joint severe longitudinal and transverse shoving (1½ inch high) had occurred on the steep, downward 3.8% grade.

In the southbound lane less severe wheelpath rutting was noticeable, however, shoving that measured from 3/4 - 1½ inch high had occurred at each end of the bridge next to the expansion joints and in the area of the traffic lights.

To investigate the cause of shoving cores were taken from the northbound lane. A total of six cores were obtained, three from within the wheelpath area and three from the area between the wheelpaths. Four of these cores were on a relatively flat section of the bridge deck, two from the wheelpath and two from between the wheel- paths. The remaining two cores were taken from the 3.8% downward grade, one from the wheelpath and the other from between the wheelpaths.

At the time of coring it was noted that all of the cores were extremely difficult to remove due to an excellent bond at the steel deck/membrane interface. Attempts to separate the membrane from the core verified that a good bond existed between these surfaces.

Further examination of the cores indicated that the shoving problem on the Webster Street bridge was occurring within the asphalt mix. Laboratory tests, including Percent Voids, Asphalt Content, and Aggregate Gradation, were performed on the six cores to evaluate the pavement's stability. No definite conclusions for the cause of shoving could be made from these results. In general, all test results for all cores were within the specification limits for the asphalt mix design.

B. Whitehall (South Bay Bridge)

This wearing course system was evaluated in May 1982 after one winter. The only notable defects were 1/16 inch hairline cracks that had developed over the longitudinal joints where abutting steel deck plates were welded together.

Based on reports of more serious problems a second survey was made in August 1982 after 10 months of service. In the southbound traffic lane the wearing system had become disbonded and was sliding over the steel deck plates. By contrast, the northbound lane showed no evidence of distress.

The failure mode in the southbound lanes was complete disbondment between the first bituminous concrete paving course and the zinc-rich painted steel deck. This occurred at each expansion joint and resulted in the entire overlay system sliding from 12 to 18 inches away from the approach-side of the joint header. The painted deck was completely exposed in this area, and there was no visible evidence of the asphalt emulsion tack coat on the steel deck plates. Accompanying this disbondment, a general displacement or shoving of the asphalt mix occurred within most of the southbound travel lane. Cracks were torn in the surface of the bituminous paving course and bulged areas (humps) of pavement along the sides of wheelpath ruts were observed.

A definite cause of the failure of the wearing system in the southbound travel lane at South Bay was not readily apparent. However, based on observations and the comparable satisfactory performance of the northbound lane, placement of the

southbound wearing system in the cooler weather conditions of October was suspect. The northbound lanes were placed in the warmer weather of August.

Cool weather construction could affect the performance of the materials used in this wearing course system. Satisfactory performance of this system is dependent on three factors: (1) bond of the overlay system to the steel deck plates; (2) bond of the fabric membrane interlayer to the underlying and overlying asphalt pavement; and (3) stability of the asphalt paving mix. To investigate these characteristics, cores were removed from both the north and southbound sides of the structure.

In the northbound travel lane nine cores were obtained from four of the structure's six spans. Six cores were in the wheelpath area and the remaining three were taken from random areas outside the wheelpaths.

A total of five cores were drilled in the failed southbound travel lane from four of the six spans. Two cores were located in the wheelpath area, and the other three cores were outside the wheelpaths.

At the time of coring the condition of each core and their ease of removal from the steel plate deck was observed. Laboratory tests were later conducted to analyze the pavement's stability or density.

The first performance factor, bonding of the overlay system to the steel plate deck, is provided by the asphalt emulsion tack coat. Cores taken in the northbound lane were all firmly adhered to the steel plate deck and had to be pried loose. Examination of the core holes showed a well bonded and uniform coat of asphalt emulsion on the steel deck plates.

The same was not true for the southbound travel lane. All cores taken in the failing southbound side were disbonded from the steel deck plates and easily lifted out of the core hole. Examination of these core holes found only the zinc painted steel deck at the bottom, and no evidence of the asphalt tack coat. It is believed that the asphalt emulsion had failed to completely cure in the cooler weather conditions. This would explain the poor bond found between the overlay system and the steel deck plates in the southbound lane.

Bond of the "Petromat" fabric membrane interlayer at the asphalt pavement interfaces is dependent on the proper application of asphalt cement to the underlying asphalt pavement, and the proper installation (specified asphalt mix temperature) of the top course of asphalt paving. In general a satisfactory bond was observed at the membrane/asphalt interfaces in both the northbound and southbound travel lane cores.

The stability (density) of the overlay system was examined next. Pavement density is a function of the compactive effort produced by rolling at the time of paving. As more compactive effort is applied, the percent air voids is reduced. Laboratory tests were conducted on cores from the northbound and southbound lanes to determine the effectiveness of compactive effort. The results below are the average percent air voids.

	Top Course	Bottom Course
Northbound	3.47%	5.58%
Southbound	10.53%	13.92%

Clearly, both paving courses in the southbound lane had much higher air voids than the northbound side. The southbound values are significantly higher than the 4-8% air voids common for a field compacted mix of this type, and suggest an unstable mix prone to shoving.

IV. SUMMARY

Based on the results of this investigation the Bituthene 5000 preformed sheet membrane and asphalt overlay wearing system that was used on the Webster Street Bridge performed better than the South Bay Bridge system. The bond of the sheet membrane to the steel deck plates, and to the asphalt overlay, was satisfactory after eight years of service. The shoving problem that was observed occurred within the asphalt mix and was most severe on the 3.8% grade and at the signal lights where traffic starts and stops. On the level areas of the bridge deck shoving was less severe and consisted of ruts in the wheelpaths.

The wearing system on the South Bay Bridge that consisted of painting the steel deck plates with a zinc-rich paint and paving two courses of asphalt, using a "Petromat" fabric waterproofing interlayer provided varying performance.

The northbound side that was constructed during the warm summer months performed satisfactorily for three years. The southbound lanes which were constructed in the cooler weather, failed after only 10 months of service.

The entire South Bay Bridge wearing course system was removed in 1984. Rehabilitation work was performed in the summer 1984 and is being reported under Experimental Feature Project NY 84-01, "Wearing Surface for Steel Orthotropic Bridge Deck."

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